INFORMATION REQUIREMENTS IN SUPPORT OF ACCREDITATION

VOLUME II

OF THE ACCREDITATION REQUIREMENTS STUDY REPORT

FEBRUARY 1994

prepared by
Computer Sciences Corporation
711. Daily Drive
Camarillo, California 93010

for the
Susceptibility Model Assessment and Range Test (SMART) Project
Naval Air Warfare Center, Weapons Division
China Lake, California

REPORT JTCG/AS-93-SM-20

Report Documentation Page

Report Date	Report Type	Dates Covered (from... to)
00FEB1994	N/A	-

Title and Subtitle Information Requirements in Support of Accreditation: Volume 2 of the Accreditation Requirements Study Report	**Contract Number**
	Grant Number
	Program Element Number
Author(s)	**Project Number**
	Task Number
	Work Unit Number
Performing Organization Name(s) and Address(es) Susceptibility Model Assessment & Range Test (SMART) Project, Naval Air Warfare Center, Weapons Div., Camarillo, CA 93010	**Performing Organization Report Number**
Sponsoring/Monitoring Agency Name(s) and Address(es)	**Sponsor/Monitor's Acronym(s)**
	Sponsor/Monitor's Report Number(s)
Distribution/Availability Statement Approved for public release, distribution unlimited	
Supplementary Notes	
Abstract see report	
Subject Terms	
Report Classification unclassified	**Classification of this page** unclassified
Classification of Abstract unclassified	**Limitation of Abstract** SAR
Number of Pages 41	

EXECUTIVE SUMMARY

The goals of the Susceptibility Model Assessment and Range Test (SMART) Project are to develop an efficient process for the verification and validation (V&V) and configuration management (C/M) of aircraft susceptibility models and to facilitate their quick and cost effective accreditation by applying this new approach to five models frequently used in survivability analyses supporting acquisition decisions. The credibility assessment process thus defined generates various reports that provide a model user with enough information on existing verification, validation (V&V), and configuration management (C/M) data to permit accreditation with a minimum of additional effort. To make these reports most beneficial to accreditation proponents, the SMART Project undertook a study of accreditation requirements.

The study involved a review of existing instructions and directives that specify accreditation requirements, as well as interviews with personnel engaged in all aspects of model development and use, from policy makers to model users. Analysis of this information focused on two principal aspects of typical accreditation decisions: accreditation processes and information requirements. The analysis of accreditation processes is presented in a companion report. This report presents findings on the information required to accredit models.

The factors most frequently mentioned as being important for determining model suitability for a particular application were:

- Clear acceptance criteria;
- Comparison of model assumptions and limitations with the characteristics and boundaries of the specific application;
- Model usage history and past V&V results;
- Results of V&V performed specifically for the intended application;
- Effective configuration management.

Of these factors, the need for <u>clear acceptance criteria</u> on which to base a decision was judged to be most critical. These criteria, in turn, were said to be critically dependent on developing appropriate measures of effectiveness for the particular application. Even with an accredited model, it was strongly felt that a study could produce erroneous results if inappropriate measures of effectiveness were used, even with ostensibly acceptable models.

The study findings led to recommended changes to SMART documentation products. A detailed listing of information requirements supporting accreditation decisions derived from the documents and interviews was compared to the current contents of the SMART products. Items not currently included in the SMART products were noted, and recommendations for specific additions were developed and are presented herein.

A principal finding of this study is that <u>all the information produced by the SMART process is important to most accreditation decisions.</u> Analysis also shows that the <u>current SMART process produces all the most frequently cited information</u> and, if the recommended additions are incorporated, will contain over 70% of all the information that was mentioned in this study. Those information requirements not included were only mentioned once or twice, or are redundant with other V&V information being produced by the SMART process.

An analysis of the information collected in this study reinforces the need for a standing library of up-to-date V&V information for frequently used models and simulations (M/S). With a library of such information each model user need perform only those V&V tasks tailored to changed portions of the model(s) or applicable to unique scenarios. If this additional information is then fed back into the V&V library, each subsequent user has a greater body of information on which to base accreditation. The products being produced by the SMART Project form a ibrary of standard data that serves to improve the quality of the V&V information available and increases the efficiency of the accreditation process.

Given the current DoD and service emphasis on the use of accredited M/S in system acquisition, considerable interest has been exhibited in various VV&A approaches and the costs of each. To address these concerns, the SMART process has been divided into increments that can be performed sequentially. Each incremental task yields a product that adds to the overall library of V&V information on a model. Use of the SMART products in accrediting ESAMS, ALARM or RADGUNS for a specific application will save the typical user a significant amount of time and money that would normally be spent in collecting V&V information for each accreditation decision. Adoption of the SMART process as the V&V methodology by all users of a model will facilitate the task of keeping the library of V&V data current as the model undergoes revision. Expansion of the SMART domain to other M/S, and adoption of the incremental approach for applying the process will benefit a correspondingly wider community of users. Use of the SMART process in producing application-specific V&V results in support of future accreditation decisions will also minimize the amount of variability that exists in the quality and scope of V&V that is done.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

1. BACKGROUND AND PURPOSE

The goal of the Susceptibility Model Assessment and Range Test (SMART) Project is to develop, document, establish, and transition a process for assessing the credibility of models and/or simulations (M/S) used in the aircraft survivability discipline. The impetus for this goal is to support acquisition decisions (e.g., Cost and Operational Effectiveness Analyses [COEAs] and Defense Acquisition Board [DAB] reviews); test planning and analysis during the development test (DT) and operational test (OT) phases of a program; mission planning; and many other applications requiring analysis of the combat effectiveness of military aircraft. The M/S credibility assessment process involves elements of verification, validation (V&V) and configuration management (C/M). Implementation of this process yields the core information required for accreditation of survivability M/S used in analyses. SMART is producing baseline V&V and C/M information on a range of aircraft survivability M/S, and building an accreditation support data base that allows M/S users to learn from and build upon the work of previous M/S users. In this way, M/S accreditation requirements in support of acquisition are more easily identified, and accreditation is more easily (and cheaply) performed.

To maximize the utility of SMART V&V and C/M documentation to the accreditation process, it became necessary to understand what information is typically required to support accreditation. Since a single source of accreditation information requirements did not exist, SMART commissioned a study to identify the requirements of the various activities that use and accredit M/S across the services. It was intended that comparison between these requirements and the current SMART products would provide useful insight into what information should be added to make SMART products most useful to those involved in actual accreditation decisions.

To establish a common understanding of the purpose and requirements of this study, it is necessary to understand the meaning of the terms verification, validation, configuration management, and accreditation. Although the definition of these terms varies from user to user, the community has generally adopted the definitions formulated by the Military Operations Research Society (MORS):

> Verification is the process of determining the degree to which an M/S accurately represents the developer's conceptual description and specifications. Verification entails a logical evaluation (evaluating inputs, outputs and code to assess whether the algorithms, equations, and results are logical) and a code verification (assessing the actual computer code using a "reverse engineering" approach to determine whether it accurately reflects the developer's specifications for algorithms, equations, and operational capability).
>
> Validation is the process of determining the degree to which an M/S is an accurate representation of the real world from the perspective of the intended uses of the M/S. It is not an absolute statement of M/S fidelity, but an ongoing process of establishing and increasing the accuracy and confidence levels of the M/S for particular applications. This process requires expert assessment of the information used in basic M/S relationships, sensitivity analysis to determine the parameters and algorithms of key importance to M/S results, and comparison of M/S

predictions with real world test data. In many cases, the term “validation” also applies to the input data that is used in M/S runs.

Configuration Management is the process of applying technical and administrative oversight to identify, document, and control the functional requirements and capabilities of M/S, control changes to their capabilities, and document, report and distribute these changes to users in a timely fashion.

Accreditation is the official determination that a particular M/S is acceptable for a particular application. It includes the judgment that the expected accuracy and confidence limits of the M/S are adequate for the intended purpose. It also assumes, implicitly or otherwise, that some form of verification, validation, and configuration management (as described above) has occurred, and that it is sufficient for the purpose at hand.

Other terminology used in this report reflects the terminology used by various sources from which this information was drawn. Different sources used the terms model, model and simulation (M&S), and model and/or simulation (M/S) to mean the same thing. Since some sources are quoted in this report, these terms are used interchangeably depending on the source under discussion.

2. STUDY APPROACH

Information for this study was collected through personal interviews and document reviews. Key individuals in the M/S community were contacted to determine the key DOD and service organizations and activities that use survivability M/S and perform verification, validation and accreditation (VV&A) in conjunction with their use. A list of these organizations was developed and points of contact at each organization were identified (see Appendix A). An interview guide was prepared to ensure that all critical questions and issues were addressed. The interview guide is contained in Appendix B.

These various organizations on the list were visited to interview those persons who perform V&V, develop VV&A policies, or approve and accredit M/S as part of their organizational function. Besides questioning the interviewee using the prepared guide, any written material that addressed VV&A guidelines, and established policy, or that documented actual VV&A efforts, were obtained. Information on other suggested points of contact was also requested, thereby broadening the interview base as wide as possible. Summary notes documenting the substance of each interview were prepared and provided to each interviewee for review and comment. This practice ensured that interview statements were clearly understood and that no bias was introduced into the interview summaries. Summaries of the interviews are provided as Appendix C. They are organized in the order shown on the interview list.

These interview summaries, along with the documentation collected, were reviewed to identify the types of information that were used to support selection of particular model and justify an accreditation decision for a study. A listing of information critical to accreditation decisions was prepared. Due to the differences in terminology used by different individuals and services, common terms were developed to represent similar information elements. A matrix was then prepared showing which elements from the list had been identified as important to each accrediting agency or activity and how frequently they were identified as being important. The most frequently cited items in that matrix were then compared to the information elements of the various reports that are produced from the SMART V&V and C/M processes. Any disparities were noted. A list of important accreditation elements that were lacking in the SMART products was identified for recommended incorporation into those products.

In compiling information requirements that support accreditation, a wide disparity was noted in the scope and depth of these requirements. This disparity paralleled (and was apparently related to) the wide variety of opinions and ideas regarding proper processes and procedures used to accredit a model. Some examples of this variability can be seen in the interview reports for the Navy's Operational Test and Evaluation Force (OPTEVFOR) and the Army Material Systems Analysis Activity (AMSAA). OPTEVFOR requests assistance from another Navy activity, the Center for Naval Analysis (CNA), to conduct an accreditation study and to provide a report that recommends whether or not a model should be accredited. There is little guidance provided by OPTEVFOR on what information should be considered, or on what criteria should be used to make such recommendations. On the other hand, AMSAA has a detailed process that entails a study of specific aspects of a model. Their study requirements are specified in a briefing checklist that identifies specific V&V information requirements, including: model development history; code review results; documentation review; data certification; previous V&V results; specific validation results; configuration management provisions; and acceptance criteria for judging model acceptability. This variability indicates that, in practice at least, accreditation requirements are in the eye of the beholder.

Although the initial objective of this study was to determine the information most frequently used to accredit models, the focus of the study was expanded when it became apparent that the emerging accreditation policies differed markedly from the current practices. These differences had to be understood to determine if the current information requirements would be likely to change as new policies are implemented. Therefore, a more detailed analysis of the various accreditation processes was undertaken. The discussion of the different accreditation practices and policies establishes the framework for analyzing the current information requirements and determining which elements are most important. The results of this policy and practice analysis are presented in a companion report entitled "A Comparative Analysis of Tri-Service Accreditation Policies and Practices," Volume I of Report # JTCG/AS-93-SM-20.

3. INTERVIEW FINDINGS

The most significant points addressed by persons from several different organizations concerned: 1) resource constraints; 2) lack of common V&V techniques and approaches; and 3) problems associated with selecting a model for a study. The major points gleaned from these summaries are highlighted in the following paragraphs. Detailed interview summaries are presented in Appendix C.

3.1 Resource Constraints

Several interviews, most notably those at AMSAA and CNA, mentioned VV&A cost as an important consideration. The value added by collecting extensive information to support accreditation must be weighed against the cost and personnel required and the importance of the decision. Concerns were also expressed about the cost of formal configuration management procedures, the cost of applying the SMART V&V process to other models, and the need to collect data on actual costs of performing V&V. (SMART is addressing this in its FY94 tasking.)

Other interviewees pointed out that there is seldom enough time to carry out a formal model accreditation for a particular application since the study results are often required in the matter of a few weeks. The organizations faced with this type of problem are the Army Deputy Chief of Staff for Operations (DCSOPS), the Naval Air Systems Command, Warfare Analysis Division (NAVAIR-526), OPTEVFOR, and the Air Force Aeronautical Systems Command (ASC). Occasionally, the lack of time forces analysts to use models that are not really suited to the study but are either the only ones available or the only ones with which the analyst is familiar.

These concerns about the cost and time required to collect extensive information about a model stem from the lack of common information requirements to support accreditation. If there were common information requirements, a library of up-to-date V&V information could be established for the most frequently used models. Such a library should contain a standard set of information elements that are most frequently used by a majority of model users. Through this analysis of accreditation information requirements, the SMART project intends to define a common set of information requirements and to establish a library of V&V data that fulfills most of these requirements.

3.2 V&V Techniques

Several V&V techniques were mentioned as being valuable in supporting accreditation. Although almost all interviewees recognized the desirability of performing extensive verification code checks and in depth comparisons between model results and real world data, funding and time constraints usually preclude such extensive V&V. Instead, many model users turn to other less costly methods that are also less beneficial. Such methods typically include reviews of past model usage and VV&A results, face validation, and some comparisons between models (commonly referred to as “benchmarking.”). Among those who use these methods are the Army Operational Test and Evaluation Command (OPTEC), the Army Aviation and Troop Command (ATCOM), AMSAA, the Air Force Operational Test and Evaluation Center (AFOTEC), ASC and NAVAIR-526. A common view is that past usage, coupled either with reviews by subject matter experts (SMEs) or comparisons between models, are sufficient to justify model selection and use. Detailed comparisons between the model results and test data are made by organizations engaged in test programs such as AFOTEC and OPTEC. These comparisons are made in parallel with the analysis being performed using the model. Several interviewees specifically mentioned the value of understanding the assumptions and limitations and performing a sensitivity analysis.

AMSAA and OPTEC have employed automated (Computer Aided Software Engineering, or CASE) tools with some success. However, the analyst needs a good understanding of the tools available and how they are best applied. According to CNA, the best use of these tools is to document the software; current model users are generally hindered by poor documentation.

A prime factor mentioned by a number of persons is the importance of well-qualified analysts. CNA, Air Force Studies and Analysis Agency (AFSAA), ATCOM, and some divisions in ASC rely on good analysts to understand the models they use and ensure that they will produce reliable results. They feel that an analyst who uses a few models on a regular basis knows model limitations well and is best suited to determine if the model is applicable to a particular study.

One other concern related to V&V techniques is data validation. Many organizations addressed this issue in the documentation provided as part of the interview. Both OPTEC and ASC personnel stressed that study validity was directly related to using valid data from an approved source for a study.

The variety of V&V techniques as well as the other factors mentioned introduce a potentially great amount of variability into the depth and breadth of the work done to support an accreditation decision. This variability can be mitigated through the development and use of standard sets of accreditation information requirements, as well as standard processes to generate supplemental information. Agreement on a common set of information elements, as defined, for example, by this study, will reduce some of the variability in accreditation justification. Use of the SMART products as a V&V baseline coupled with adoption of the SMART process to generate supplemental V&V information will further reduce this variability.

3.3 Model Selection Concerns

One point brought out by both the OPTEC and the Air Warfare Center (AWC) interviewees seems obvious but is so important that it bears repeating. Using an accredited model is not the only key to obtaining valid study results. The correct measures of performance (MOPs) or measures of effectiveness (MOEs) for the study must be chosen before the study begins. The use of inappropriate MOPs or MOEs can lead to erroneous study results, even if the model used to support the study is an accurate representation of “reality.” Appropriate MOEs or MOPs should be derived from the study objectives early on. This point cannot be overemphasized in light of the relationship between study MOEs and model acceptance criteria, a point that will be amplified in later paragraphs. OPTEC has a guide for choosing their M/S acceptance criteria, and AMSAA has included M/S acceptance criteria as a major item in their accreditation reviews.

The stated need to identify appropriate MOEs or MOPs and from them to define proper acceptance criteria for a model points to the benefits of having a library of V&V information that can be compared to these acceptance criteria during the model selection process. This concept of acceptance criteria and a library of V&V information requires that validation results should be stated in terms of model limitations or objective statements regarding correlation fidelity. Only with objective statements of model fidelity can a user make an independent comparison between the model capabilities and the acceptance criteria for a particular application. A methodology for developing appropriate MOEs and MOPs and defining acceptance criteria is discussed further in the accompanying volume to this report entitled “A Comparative Analysis of Tri-Service Accreditation Policies and Practices,” Volume I of Report # JTCG/AS-93-SM-20.

Another issue mentioned by a large number of interviewees was configuration management. Knowledge of all changes to a model that make it different from the one described in the model's baseline documentation was deemed essential to determining its suitability for a particular application. Many also expressed concerns over the time it takes to get proposed and required changes incorporated, tested, and distributed to the users.

The expressed concerns about configuration management point out the importance of being able to relate V&V information to a particular version of a model. This concern is the basis for the SMART project efforts to develop common configuration management requirements and guidelines that are linked to the V&V process, so that the user has a means of relating the V&V results to all applicable model versions.

4. INFORMATION REQUIREMENTS ANALYSIS

The preceding section highlighted the important elements extracted from the interview summaries. To ensure that the SMART products contain most or all the information needed by study analysts gathering accreditation support information, a listing of all data items mentioned by any of the interviewees was developed. A matrix showing these information elements is shown in Table 1. Where different organizations cited an information element that appeared to be similar to one cited by another organization albeit using different terminology, a common term was defined to cover both information elements. Furthermore, in identifying information elements, each activity or organization cited the various elements in different ways. Some of the elements were cited as requirements; others were listed as examples of what might be appropriate; still others were cited as actually used in a recent accreditation. A key to the matrix entries is given in Table 2. Definitions of the terms used to describe the information elements in the matrix are contained in Appendix D. An understanding of these terms is essential to the following discussion.

The organization of the information elements in the matrix is somewhat subjective. Although verification and validation are done in support of accreditation, most of the interviewees and documents identified these functions as separate activities. Verification and validation are generally the responsibility of analysts, whereas accreditation is performed by an executive agent. Because these functions are generally treated separately by M/S users, they are listed and discussed separately in this report. The information requirements for accreditation are divided into three categories: those that support decisions for a "class of applications"; those that support decisions for a specific application; and those that are needed for both types of accreditation.

TABLE 1 ACCREDITATION REQUIREMENTS MATRIX (SHEET 1)

ACTIVITY	TOTAL	USA	DCSOPS	AMSAA	OPTEC	USN	CNA	OPTEVFOR	PMA	AIR	AFSAA	AFOTEC	ASC	WPAL
		Policy				Policy			281	526				MOSAIC
VERIFICATION REQUIREMENTS														
Logical Verification	11													
Documentation Review	3	E		R	E									
Rev Assmp'ns/Constr'ts	7	E		R		CL	R	A		I		A		
Input Data Interfaces Ck	4		A	R	E					I				
Design Logic Checks	4	E	A		R	CL								
Algorithm Logic Cks	6	E	A		E	CL	R					A		
Code/Spec Comparisons	1	E												
Peer Review	5	E		A	E, P	CL							A	
Verify M/S Specification	3	E				DV								R
Time/Step Size Impacts	1						R							
Code Verification	10					CV			D					
Algorithm Code Cks	3	E			E, P							A		
Sensitivity Analysis	6	E	A		R		A						A	I
Code Walk Throughs	4	E		A	E							A		
Automated Test	4	E		A	E							A		
Tools Stress Testing	3	E		A	E									
Mathematical Stability Ck	1	E												
Units Ck	3	E			E		R							
Internal Consistency Cks	2				E		R							
Stochastic Model Statistic Tests	1	E												
Rule Based Systems Tests	1	E												

TABLE 1 ACCREDITATION REQUIREMENTS MATRIX (SHEET 2)

ACTIVITY	TOTAL	USA Policy	DCSOPS	AMSAA	OPTEC	USN Policy	CNA	OPTEVFOR	PMA 281	AIR 526	AFSAA	AFOTEC	ASC	WPAL MOSAIC
VALIDATION REQUIREMENTS														
Real World Applications Defined	11	R		A	R, P	CL	I		R	I	I	A	A	A
Key Application Criteria Def Ck	8	R		R	R, P		I		I	I		A		I
Assumptions/Constraints	6	R		R	R		R				I	A		
Face Validation	6	E		A	E, P	RV				A, P		A		
Benchmarking	8	E	A	A	E, P	RV			E	A, P		A		
Process Sample Data	3				R				R				A	
Functional Decomposition	2	E												R
Independent Review	4	E		A	E, P	RV								
Sens. Analysis - Stress Test	5	E		A	E, P	RV						A		
Data Comparison	8	E	A	A	E, P	RV			E			A		R
Any Accredited Algorithms	2		A	A										
ID Non Validated Model Elements	1											A		
EE Correlation w Manuf. Info.	1													R
Correlation w Intel Data	1													R
Data Validation	6	R		A	P				A				A	R
ACCREDITATION REQUIREMENTS (CLASS OF APPLICATIONS)														
Review Assump/Limits	3	R			I									R
Establish Accred. Criteria	6	R	A	A	I	DA, SA						A		
V&V Documentation Ck	7	R		A	E	DA, SA	I	A				A		
Accreditation & Usage History	7	R	A	A	E	DA, SA		A				A		
Compliance with Prof. Stds.	1					DA, SA								
ACCREDITATION REQUIREMENTS (SPECIFIC APPLICATION)														
Scenario/Data Inputs Ck	5	R		A	E	DA, SA								R
Specific Acceptance Criteria	4	R		A	R, P							A		
Operator/Analyst Expertise	3				E	DA, SA	I							
Independent Review Group	1											A		

TABLE 2 ACCREDITATION REQUIREMENTS MATRIX DATA ENTRY KEY

CODE	DEFINITION
A	Addressed - Information on the indicated item is requested
E	Example - Although not specifically cited as an accreditation item, the indicated item is cited as an example of what is expected
I	Implied - Although not specifically cited as an accreditation item, the indicated item is necessary to meet some other specified requirement.
P	Performed - Item was included in an actual VV&A report for a specific model or simulation.
R	Required - The indicated item is required for accreditation.

4.1 Information Elements Supporting Verification

Since "verification" is the process of determining that the model accurately represents the developer's intentions, and that this representation meets identified requirements, the critical factors are understanding the requirements and knowing how the developer intended to meet (or actually met) them. Any requirements documents or conceptual specifications, as well as the various manuals describing model operation and use, are the best sources of this information. The availability and adequacy of these materials is one of the factors deemed most important to an accreditation decision, because they form the basis for code checks and because they facilitate ready identification of M/S limitations and constraints.

The two principal aspects of verification identified by the study participants were logical verification and code verification. Logical verification consists of those reviews meant to ensure the accuracy and consistency of a model's assumptions, equations, and algorithms. A thorough review of the assumptions and limitations was considered essential to understanding a model. Users wanted to know both explicit and implicit assumptions and limitations of the model in order to understand how best to use it. These assumptions and limitations, along with the various model descriptions, provide an insight into the developer's intended design, form the basis for any verification effort, and are critical to determining that a given model is suitable for use in a particular application.

The other commonly cited aspect of logical verification was a review of the basic algorithms to ensure that they adequately portray reality and are applied in the appropriate regimes. The parametric boundaries beyond which the mathematical approximations no longer reflect real world phenomena can be deduced from a “walk-through” of the algorithms and equations. For example, the algorithms used to represent normal aircraft cruise performance should be checked to ensure that they are not employed at low speed and high angles of attack where the linear assumptions about lift and drag are no longer valid. These logical checks are often performed by independent SMEs or independent analysts and are frequently termed "peer reviews" Such reviews are commonly used as part of verification.

Other reviews that are performed as part of the logical verification include documentation checks and design logic checks by SMEs. These are done to verify that the flow diagrams, model structure, and process descriptions are consistent and acceptable from the perspective of system experts. Another review, included under logical verification but more closely related to the input data used in an application, is a check on the consistency of data definitions between the source data and that specified for the model inputs.

Code verification is a detailed and (often) laborious comparison of the code to the model software specifications. If the specifications do not exist (a common circumstance for many existing models) the verifier must develop them through an analysis of the existing manuals and through reverse engineering of the code, frequently in conjunction with the original model developer. Such efforts are time consuming and can be costly. Therefore, in-depth code verification is seldom done in support of current accreditation decisions.

One technique that was cited as important to verification, but also applies to validation, was a sensitivity analysis. It allows an analyst to determine which input parameters and/or model subroutines have the most significant effect on model outputs. It provides a means of determining that the code is functioning properly for varying sets of input data. A sensitivity analysis of model input and output relationships can also serve to define hidden assumptions and limitations. A sensitivity analysis also provides the basic information needed to check that the model is reacting to varying inputs in a reasonable and mathematically predictable manner. Their results also increase confidence that the model is sensitive to those parameters that tend to cause the greatest perturbations in real world results. The information resulting from the sensitivity analyses is also important in reaching an accreditation decision. The effect of M/S outputs on the MOEs or MOPs used in the analysis can be evaluated in light of the sensitivity analysis results.

In many cases, the results of these sensitivity analyses are used to structure stress tests (i.e., test runs of the model using limit values for certain parameters) to study the effects of extreme inputs on model results, or to determine that the model will not "crash" under these conditions. Stress testing is time consuming, but is considered important in those studies where the study boundaries are near or outside the accepted model envelope.

Because the results of sensitivity analyses give the analyst wide ranging insights into the model and its limitations, this technique is considered important for generating accreditation information. It is an essential component of in depth V&V.

Finally, automated software tools (CASE tools) were also indicated as being useful to the verification effort. Such tools can assist in documenting previously undocumented code, developing flow charts, and identifying portions of the code most likely to contain errors. Although not a direct source of accreditation information, these tools are a major aide to performing in depth code checks on M/S.

4.2 Information Elements Supporting Validation

Validation is a comparison between test data and model predictions when the model is run under the same input and environmental conditions as the test. In order to validate a model, a clear definition of the real world conditions is essential. This definition must include criteria by which the adequacy of the model's representation of the real world can be judged. These criteria will typically include accuracy and sampling rates required for statistical confidence in the comparison between test data and M/S predictions. (For example, how closely must the test data agree with model predictions and how frequently must data measurements be made to generate confidence in this result.) The definition of real world conditions and application criteria are the responsibility of the model user, and are prerequisite to evaluating validation results.

Once the real world application is defined and understood, and the application criteria have been clearly established, the comparisons between model results and test data results are the next most important element of model validation. The model user is not necessarily forced into performing dedicated tests to make these comparisons. In fact, for some classes of models (e.g., force on force), adequate tests cannot be conducted. With a clear understanding of what information is required about the real world, however, the model validator can use existing data from tests, operations, or even combat as a basis for comparisons. The one key factor in determining data utility is adequate descriptive documentation, which must provide enough information to allow an evaluation of whether the data meet the defined real world description criteria.

Sensitivity analyses are also important in the validation effort. The model must be compared to the real world on the edges of the application envelope. Sensitivity analyses determine which parameters have the greatest impact, and which are most likely to cause significant variations in the results at the edge of the envelope.

Other validation techniques (employed when test data are not available, when they cannot be economically obtained, or when time prohibits an adequate data collection effort) are "benchmarking" and "face validation”. Benchmarking is the comparison between a model's output and the outputs of other models or simulations, all of which represent the same input and environmental conditions. The tacit assumption is made that two or more models will not be equally “wrong” in their predictions of the outcome of a given phenomenon, and that good correlation among and between model results indicates “reasonableness.” Benchmarking is not included as a technique in the SMART process. However, the SMART accreditation support database (ASD) will include results of any benchmarking done by other organizations in the course of gathering their own information to support their specific accreditation. Inputs regarding any VV&A efforts by all model users will be incorporated in the database and will be available for new model users.

Face validation is the technique of reviewing the model, its algorithms and equations, by a group of subject matter experts to determine if they appear logical and yield reasonable results for known input conditions. This is very similar to the same type of review described as a component of verification. In the former case, the focus of the SME review is on the implementation of a given algorithm in the code; in the latter case, the focus is on the reasonableness of the algorithm's results for a given application. The boundary between this aspect of verification and face validation is indistinct.

Many model users cited data validation as a major consideration in any accreditation decision. Data validation is ensuring that the data to be used in a study are representative of the real world. Since there are numerous data sources for each model, data selection is uniquely dependent on each particular application. Data validation is most efficiently done by each model user.

4.3 Information Elements Supporting Configuration Management

Configuration management is also a significant concern of the study participants. Adequate configuration control is needed to assure the model user that the version of the model being used matches documented characteristics, and that any model changes from the documented version are identified. A configuration management system will also allow the accreditation proponent to relate past accreditation and usage information to a particular model version, and to assess the applicability of that historical information to the current application.

Configuration management requirements are also specified in the Army's AR 5-11 and the draft Navy VV&A principles (see companion volume of this report for a discussion of these directives). The draft Air Force policy did not address configuration management. However, the policy is undergoing multiple reviews and will likely be modified to include configuration management requirements. All of the configuration management requirements are focused on having the ability to track model changes and ensure that the V&V results are applicable to the version of the model used in a particular application.

4.4 Information Elements Supporting Accreditation

In addition to verification and validation results, information in other categories must be collected and reviewed to satisfactorily accredit a model. This information falls into four categories: model descriptions; model documentation; configuration management data; and V&V documents. For any accreditation decision, a clear description and understanding of the model to be used is essential. This description includes several subelements as shown in the information requirements matrix. Model features must be known and clearly understood to permit a comparison with acceptance criteria. Model V&V reports produced by the SMART project will provide nearly all the necessary information to meet these needs.

The availability and adequacy of model documentation is an area of concern to an accrediting authority. The most commonly identified manuals required for accreditation are the User's Manual and the Analyst's Manual. According to a number of study participants, these manuals are the very minimum required to understand a model and use a model knowledgeably in a particular application. The documentation review that is conducted as part of the SMART process ensures that these documents meet the minimum needs of a model user by comparing the current status of model documentation with identified accreditation requirements.

Plans and reports that document VV&A efforts are required by many of the organizations that have formalized accreditation processes. A formal accreditation report was the most frequently cited document needed to support accreditation. Two of the organizations, PMA-281 and the Navy Operational Test and Evaluation Force (OPTEVFOR) desire or require an accreditation report, since they rely on external sources for accreditation recommendations. OPTEVFOR identifies the models they intend to use and requests an accreditation study on those models from the Center for Naval Analyses. The respondent report serves as the basis for an accreditation decision by the Commander, OPTEVFOR. PMA-281, the Cruise Missile Project Office, does not have anyone performing formal accreditation studies. However, they would like to have such a study done on the models they use so that the analytical results would be more credible.

Besides the general accreditation support information discussed above, other information was identified as required to support accreditation either for a class of applications or a specific application. The most frequently required information to support a class of applications (or domain) accreditation decision is: V&V Documentation, Accreditation & Usage History, and Acceptance Criteria. The first two elements are important to users because they provide, in summary form, a broadly based statement of confidence regarding the model along with a definition of the applications for which the model, was deemed suitable. These elements can also provide leads for sources of additional V&V information that might be helpful in accrediting the model for a specific application. The Accreditation Support Database being developed by the SMART Project will provide the vast majority of this information.

The third information element, Acceptance Criteria, is considered the most important factor in supporting an accreditation decision, considering the number of categories in which this one element is cited as a requirement. Acceptance criteria are needed for both domain and application specific accreditation, as well as evaluating validation results. Their importance is also supported from a logical perspective. Without well-defined acceptance criteria, any judgment concerning model suitability for an application is purely subjective. Acceptability criteria are the key information element required to reach any accreditation decision. A list of sample questions that might be used to guide the selection of acceptance criteria is provided in Appendix E.

There are two potential risks in not defining acceptability criteria and relying on subjective judgment of model suitability. The first is that the model may not accurately predict real world outcomes throughout the envelope of interest and yet it might be accredited, thus yielding erroneous study results. In this case, major programmatic and funding decisions may be in error, resulting in a waste of both time and money. Such errors can be minimized or eliminated through clear definition of acceptability criteria that clearly delineate the boundaries within which the M/S must perform acceptably. A second, and more likely possibility is that a model might undergo excessive V&V in order to be made as perfect as possible, leading to excessive accreditation costs. A clear definition of acceptance criteria gives greater confidence that an M/S can be accredited without an excessive expenditure of funds to create a near perfect replication of a real system or phenomenon.

To accredit a model for a specific application, the most frequently cited information requirement besides acceptance criteria was the correlation of scenario and input data with the model's requirements. The comparison of the scenario and data elements of the particular application with those of the model helps ensure that the model addresses all of the elements of the real world that apply to the problem being analyzed. It is also the basis for comparing the model limitations to the problem boundaries to ensure accurate model results throughout the problem domain.

5. SMART SOURCES FOR REQUIRED INFORMATION

Any information elements cited as being important for verifying, validating, and accrediting a model are listed in Table 1 and are repeated in Table 3 to show correlation with the SMART products. The second column in Table 3 identifies the SMART product that contains the indicated type of information. Some of the information elements are not currently included in the SMART products but can be added with relatively little additional effort; the third column shows which products could be modified to include the indicated information.

Some of the information can only be derived from the analytical problem (e.g., acceptability criteria, real world descriptions, scenario descriptions, etc.). Such information must be obtained by the analyst responsible for the study through an analysis of the study requirements, MOEs, and objectives. Those elements are identified as the "analyst's responsibility."

Other information elements are not considered important by a wide number of users, or are not applicable to the susceptibility models that are the subject of the SMART process. In those cases the element is shown as "not addressed." An explanation of the rationale for each of the third column entries follows.

5.1 Information Requirements Supporting Verification

The verification process undertaken as a part of the SMART process already includes the most frequently mentioned and most beneficial verification steps. These are a check of assumptions and constraints, algorithm logic checks, documentation reviews, design logic checks, sensitivity analysis, automated test tools use, and, most importantly, code walk throughs. During the logic checks, a units check is made to ensure that proper units of measure are specified and are consistent with the units in the model equations. The SMART products, as presently constituted, provide a significant amount of the most frequently needed verification information. That information not included is discussed in the following paragraphs.

The Input Data Interfaces Check is a review of input data sources for correctness from the perspective of the intended application. It also includes a check for consistency of definitions and units of measure between the data sources and the model. This verification technique requires a knowledge of the data sources and the particular application. Therefore it must be done by the analyst for each application. It is not appropriate or feasible to perform this type of verification universally for all applications. Thus SMART does not include the results of this particular technique in any product.

TABLE 3 SMART PRODUCT CORRELATION (Sheet 1)

ACTIVITY	CURRENT SMART SOURCE	RECOMMENDED SMART SOURCE
VERIFICATION REQUIREMENTS		
Logical Verification		
Rev Assumptions/Constraints	Verification Reports	
Algorithm Logic Checks	Verification Reports	
Documentation Review	Verification Reports	
Input Data Interfaces Check		Analyst's Responsibility
Design Logic Checks	Verification Reports	
Peer Review		Not Addressed
Code/Spec Comparisons	Verification Reports	
Verify M/S Specification	Verification Reports	
Time/Step Size Impacts		Analyst's Responsibility
Code Verification		
Sensitivity Analysis	Validation Reports	
Automated Test Tools	Verification Reports	
Algorithm Code Checks	Verification Reports	
Code Walk Throughs	Verification Reports	
Stress Testing		Not Addressed
Units Check	Verification Reports	
Internal Consistency Checks		Verification Reports
Quality Verification	Verification Reports	
Acceptance Testing - Verification		Not Addressed
Mathematical Stability Check		Not Addressed
Stochastic Model Statistic Tests		Not Addressed
Rule Based Systems Tests		Not Addressed
VALIDATION REQUIREMENTS		
Real World Applications Defined		Analyst's Responsibility
Key Application Criteria Defined		Analyst's Responsibility
Data Comparison	Validation Report	
Benchmarking		ASD
Check Assumptions/Constraints	Validation Report	
Data Validation		Not Addressed
Face Validation	Validation Report	
Process Sample Data		Validation Report (Based on SURVIAC's Practices)
Independent Review	Validation Report	
Sensitivity Analysis - Stress Test	Validation Report	
Any Accredited Algorithms		Not Addressed
Functional Decomposition	Validation Report	
Identify Non Validated Model Elements		ASD
FE Correlation with Manufacturer's Data		Validation Report
Correlation with Intelligence Data		Validation Report

TABLE 3 SMART PRODUCT CORRELATION (Sheet 2)

ACTIVITY	CURRENT SMART SOURCE	RECOMMENDED SMART SOURCE
ACCREDITATION REQUIREMENTS (GENERAL)		
Model Description		
Model Purpose/Usage	ASD	
In/Out Data Requirements	Model Documentation	
Model Fidelity	VV&A/CM Status Report	
Scenarios Included/Excluded.	Model Documentation	ASD
Variables Included/Excluded	Model Documentation	
HW/SW Requirements	Model Documentation	ASD
Model Development History		Not Addressed
Derivative Analysis		Not Addressed
Model Documentation		
User's Manual	Documentation Report	
Analyst's Manual	Documentation Report	
Programmer's Guide	Documentation Report	
Data Dictionary		Not Addressed
Source Code Documents	Post Development Design Document	
Test Plans/TEMP		Not Addressed
Executive Overview	VV&A/CM Status Report	
Configuration Management		
CM Status Accounting	CM Plan	
CM Internal Control	CM Plan	
CM External Control	CM Plan	
User's Group	CM Plan	
Configuration Management Plan	CM Plan	
Statement of Functional Changes		Not Addressed
VV&A Documentation		
Accreditation Report		Not Addressed
Accreditation Plan		Not Addressed
V&V Plan	SMART Process Descriptions	
V&V Report	VV&A/CM Status Report	
ACCREDITATION REQUIREMENTS (CLASS OF APPLICATIONS)		
Accreditation & Usage History		ASD
V&V Documentation Check		ASD
Establish Accreditation Criteria		Analyst's Responsibility
Review Assumptions & Constraints	Verification Reports	ASD
ACCREDITATION REQUIREMENTS (SPECIFIC APPLICATION)		
Scenario/Data Inputs Check		Analyst's Responsibility
Specific Acceptance Criteria		Analyst's Responsibility
Operator/Analyst Expertise		Not Addressed
Independent Review Group		Not Addressed

A Peer Review requires that a team of subject matter experts review the logic of the model algorithms and reach a consensus that the model represents their understanding of the real world. Although the SMART process includes a logical verification of the model algorithms by the independent verifier, it does not include any reviews by independent subject matter experts. It is felt that actual comparisons with test data provide a more rigorous means of ensuring that the model represents the real world and fulfill a larger set of user requirements for credible models. The SMART process does include an end-to-end assessment of the model validity by an independent validator. This assessment is done based on comparisons between model outputs and real world data. The results of this end-to-end assessment are reported in the validation reports. Any results of previous Peer Reviews would be included in the SMART Accreditation Support Database (ASD) under the data elements related to previous V&V results.

Time-step Size Impacts Assessment requires that the analyst check that the step size employed by the model is fine enough to detect any changes of interest in the particular application. This comparison can only be done based on an understanding of the real world nature of the intended application. Therefore the SMART products do not include any time-step size impact assessments.

Three code verification techniques that are not addressed in the SMART products are: stress testing, acceptance testing, and mathematical stability checks. Stress testing is a technique whereby the model is run with sample input data to ensure that the outputs are realistic. Input data is generally selected at the boundary conditions, using combinations of input parameters that have been determined to be critical through sensitivity analyses. The SMART verification process does not include this type of technique. However, the model developers, in performing sensitivity analyses on some functional elements, do conduct runs using boundary parameters. Their purpose is to show that the outputs of the functional element are reasonable. They report the results of such runs as face validation of the particular functional element.

Acceptance testing is an independent operational check of the model software by the receiving agency. This particular technique is not documented separately in the SMART products since it is the responsibility of the receiving agency.

Mathematical stability checks are special model runs on different platforms or using varying input data to check for unstable results. Special tests using different platforms were considered immaterial to the SMART process, given the responsibility of the configuration manager to ensure platform compatibility.

The other two verification techniques that are not included in the SMART process, stochastic model statistic tests and rule based systems tests do not apply to the types of models addressed by the SMART Project to date. However, some air combat models, such as TAC BRAWLER, might benefit from performing rule based systems tests. If so, the results of such tests will be included in the validation reports.

The final verification technique that is not specifically included in the SMART process is an Internal Consistency Check. This is a check that consistent units of measure for time, distance, and spatial coordinates are used throughout the model. Since the SMART process is based on doing V&V by functional element, a check for internal consistency in the total model is not done. However, as each functional element is verified, the code check does address internal consistency within that functional element. As each additional functional element is verified, consistency with units of the previous functional elements should also be checked. In this way, internal consistency will be assured once the total model has undergone a code check. The independent verifiers should specifically report the results of internal consistency checks on each functional element so that subsequent verifiers can build upon previous work and eventually check that units are consistent throughout the model.

5.2 Information Requirements Supporting Validation

The two most important factors related to validation, Definition of the Real World Application and Identification of the Application Criteria, are dependent on each particular application. Therefore, these steps are the analyst's responsibility. The SMART documents do list the intended applications for a model that can be compared to the analyst's concept of the particular application to lead to a determination that a model is suitable for a particular application.

With clear definitions of the real world conditions and the criteria that the model must meet, the actual comparison of model output with real world data can be done. This step is the heart of the SMART process and is one of the fundamental results of applying the SMART process to a model. This step is looked upon as the best means of validating an engineering model since one-to-one comparisons under controlled conditions can be made. The SMART products, as currently constituted provide this information and are a valuable source of information to a model user.

Benchmarking, while not a part of the SMART process, will be addressed in the SMART Accreditation Support Database (ASD). Any results from model user benchmark comparisons will be listed as part of the V&V history of a model. The ASD will include a listing of the functional elements that have been validated. Through a simple comparison, those not validated can also be identified, thus providing another piece of desired information.

Two of the validation elements are not addressed: Data Validation and Identification of Any Accredited Algorithms. Data Validation is a check on input data sources to ensure that the data are representative of the real world. Although the SMART Project certifies its own validation data sources, data to be used in other studies will vary for each application and the types of systems may vary from application to application. Data Validation in this context is best done by the analyst performing the study. Identification of Accredited Algorithms is a check to determine if any of the algorithms used in the model have been previously verified or validated in other models. Such a check is useful if one is unfamiliar with a model and just starting a V&V effort, but considering the extended V&V performed under the SMART process, this technique is not addressed. As part of the SMART process, a V&V status survey of the models in its domain was conducted and little or no documented work of recent vintage was found.

Information on the three remaining validation elements should be included in the SMART validation reports when feasible. The Survivability & Vulnerability Information Analysis Center (SURVIAC) processes sample data through a model when it is released to them for distribution. These runs with sample data check that a new version of a model provides the same results as the previous version for standard inputs. This check provides assurance that any modifications did not introduce unintentional changes in parts of the model that were to remain the same. It would appear to be easy to incorporate the results of these runs into the validation report at one of the periodic updates. These results could also be summarized in the ASD, which SURVIAC will administer.

The functional element correlation with manufacturer's data is applicable to U.S. or allied systems for which manufacturer's data is accessible. Since the SMART process is based on validation using actual data obtained from these systems, this specific technique provides little additional value. Such comparisons would be valuable as part of a face validation. Any results from such comparisons that are made as part of face validation for selected functional elements will be included in the appropriate Functional Element Assessment Reports.

Correlation with intelligence data is a specific requirement of the J-MASS and SIMVAL programs. The results from those programs that bear on the models in the SMART domain will be included in the ASD. Any intelligence correlation results from on going parallel SIMVAL efforts should be obtained and summarized in the VV&A/CM Status Reports and the ASD.

With these additions, the SMART products can become a single source of all or nearly all V&V information to support accreditation for models it is assessing. The only information not included will be V&V results for model changes made by the user or for specialized scenario conditions not included in the baseline data.

5.3 Information Requirements Supporting Configuration Management

The SMART Project is developing a common configuration management plan for all the models that will undergo the SMART V&V process. This plan will meet all the major C/M information requirements identified in this study. A prototype configuration management process will be established and tested on one of the SMART models during FY94. The prototype system will be used to track different model versions and relate the V&V work done by both the SMART Project and others users to each version.

"Based on the results of this prototype effort a common C/M process will be proposed for use on a continuing basis for all three SMART models. This system will meet the needs of all the model users interviewed for this study. The common C/M process will be documented in a C/M procedures guide.

5.4 Information Requirements Supporting Accreditation

Model descriptive information is currently contained in the model documentation. Some of it, such as the purpose and usage, will be in the ASD. Other elements, such as a listing of the intended scenarios and the hardware and software requirements should also be added. The items related to the model development history and its derivation from other models is not in any formal SMART report, but is frequently a part of the model documentation. The documentation assessment requirements developed by the

SMART Project do require that the model history be included in one of the manuals produced by the model developer. Any specific deficiencies in the model history are documented in the individual model Documentation Assessment Reports that are produced as part of the verification process.

The three principle model documents (User's Manual, Analyst's Manual, and Programmer's Manual) are reviewed and evaluated as part of the SMART verification process. These reviews will help ensure that these manuals meet a minimum standard of acceptability and applicability to accreditation based on identified requirements. Furthermore, based on information from these reviews and inputs from the model developer, a Post Development Design Document is developed. This document serves the purpose of the developer's software specification for verification purposes. Summaries of the contents and quality of these documents are provided in the Documentation Assessment Report. The Data Dictionary is not addressed separately in the SMART products. The documentation assessment requirements do include a requirement that adequate descriptions of input and output data be included in one of the three manuals or a separate document. Test Plan reviews are not included in the SMART process. Test plans that address model usage are unique to each application and therefore the responsibility for checking these test plans rests with the individual analyst.

The information that supports accreditation for a class of applications: namely, accreditation and usage history, V&V documentation lists, and lists of assumptions and constraints, will be included in the ASD. The assumptions and constraints are currently contained in the verification reports in greater detail. Accreditation or acceptance criteria depend on the intended application and are the analyst's responsibility.

The information requirements for application specific accreditation either depend on the intended application or are outside the scope of the SMART Project. They are not addressed in any of the SMART products.

6. SMART PRODUCT USAGE

The V&V data produced through the application of the SMART process form a library of standard information that is needed to support nearly all accreditations. Use of this library should simplify the task of developing accreditation support packages. Adoption of the SMART process for additional V&V beyond the scope of the existing data will improve the breadth, depth and quality of the V&V work done and increase the overall efficiency of accreditation efforts.

The SMART Project is developing a library of V&V information for selected models. Since the SMART process is applicable to any engineering type model, the benefits could be realized if the users of a particular model all adopted this process for their V&V work. Since the amount of information generated by application of the SMART process is extensive, development of the baseline information library requires sufficient time and resources. Individual users often will not have sufficient amounts of either to undertake the foundation work.

To realize the benefits of the SMART process without unduly burdening a single user, the process can be divided into a series of incremental steps, each of which provides a partial contribution to the baseline library and fulfills some of the information requirements identified in this study. This incremental process includes enhancements to the current SMART process that provide some initial credibility assessment prior to full validation and verification. These enhancements include a peer review to verify the adequacy of model algorithms and face validation of the whole model. The incremental approach to applying the SMART process is depicted in Figure 1. This approach would also be useful for legacy models not included in the initial SMART domain.

The diagram is arranged so that the steps are in sequential order from top to bottom. Those steps which are horizontally parallel would generally be performed concurrently. If sufficient resources were not available, the user could choose which of the horizontally aligned steps to perform based on individual needs. The arrows show which steps must be performed to yield the indicated products. The process support products are a natural by-product of the SMART process application and facilitate execution of subsequent steps.

The overall process is structured so that each V&V product provides an incremental increase in model credibility. Each model user can perform as many steps as time and resources permit. The scheme for performing the V&V and organizing the resulting information is discussed further in the companion report entitled “A Comparative Analysis of Tri-Service Accreditation Policies and Practices,” Volume I of Report # JTCG/AS-93-SM-20. Ultimately, when all of the functional elements (FEs) are both verified and validated, and overall model validation is completed and correlated with FE validation as appropriate, a library of baseline V&V data will exist that will provide nearly all of the supporting information for subsequent accreditations. With such a library of information, each model user need only perform additional V&V on changed portions of a model or for unique scenarios. If this additional information is then fed back into the library, each subsequent user has a greater body of information on which to base accreditation.

To make the V&V information collected in this process most useful, results would be stated in objective terms so that individual model users can make independent judgments regarding model suitability for a given application. Subjective terms such as “good correlation” or “compares favorably” would be avoided. Where possible, results of any comparison between model predictions and real world data would be quantified. Adherence to this philosophy would enhance the utility of validation data collected by other users. The SMART Project is currently undergoing a detailed review of the format of its accreditation support products to provide baseline examples of how such information should be structured.

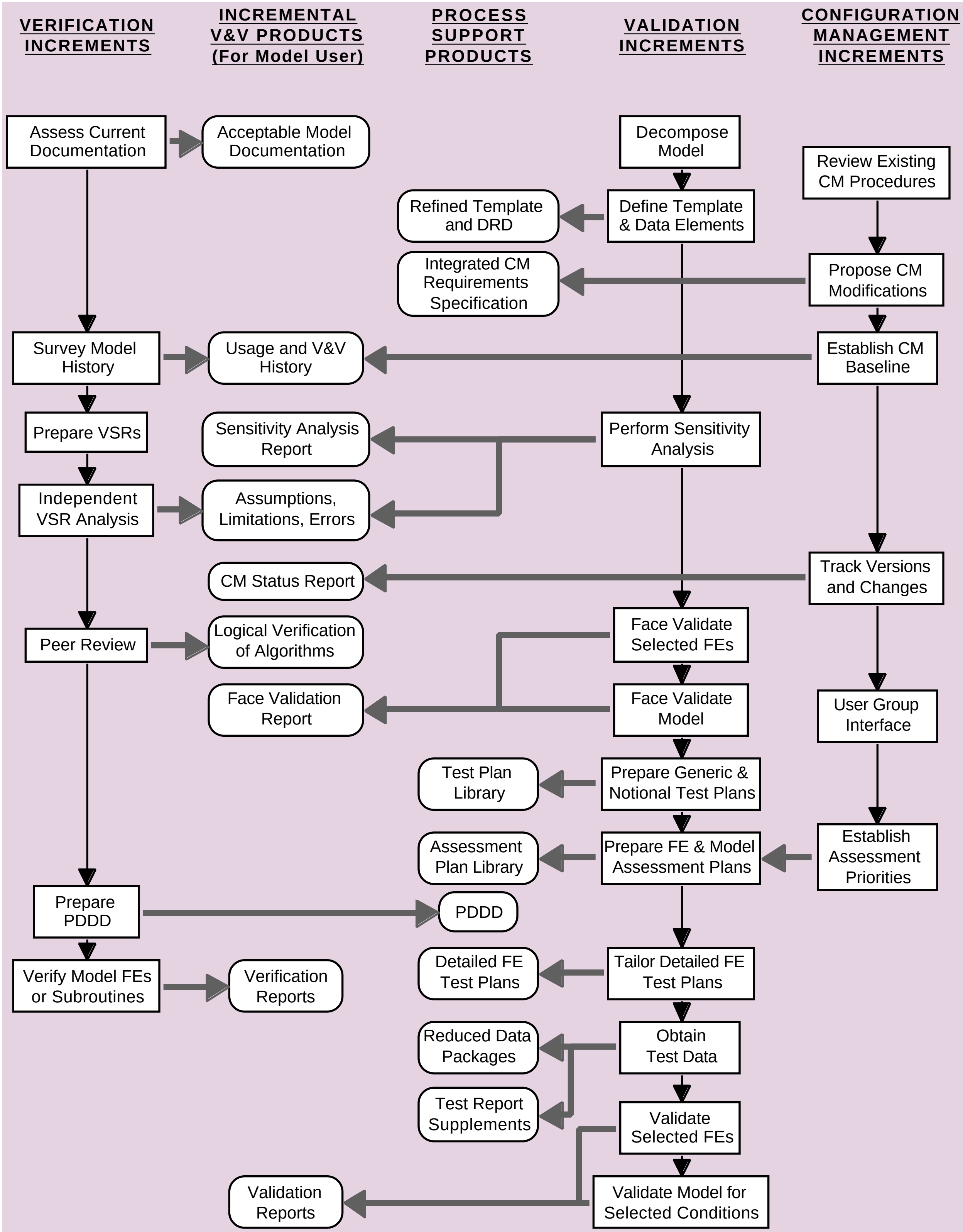

FIGURE 1 INCREMENTAL SMART PROCESS

7. CONCLUSIONS AND RECOMMENDATIONS

A principal finding of this study is that <u>all the information produced by the SMART process is important to most accreditation decisions</u>. Another finding is that the SMART process, as presently structured, produces all of the non-application-unique information most frequently cited as required to support accreditation. If the recommended additions that are listed below are incorporated, the SMART products will contain over 70% of all the information that was mentioned in this study. Information that is not included was deemed of marginal value since it was mentioned by only one or two sources or is redundant with other V&V information produced by the SMART process. Once the SMART process has been applied to a model to generate a library of V&V data, a user will only need to perform additional V&V for model changes or for unique conditions of the intended application.

Use of the SMART products will save the typical user a significant amount of time and money that would normally be spent in collecting or producing extensive V&V information. Employment of the SMART process in developing application specific V&V results will also minimize the amount of potential variability that exists in the quality and scope of V&V that is done and will provide additional information in a standard format for future users.

To realize the benefits of having a library of standard V&V data, and to make that data most useful, the following recommendations are submitted.

1. The processes for determining study MOEs and MOPs outlined in the companion volume to this report should be adopted.

2. V&V results from the SMART Project should be stated in objective terms relating to model limitations and constraints.

3. SMART reports and the ASD should be tailored to include the information elements indicated in Table 3. Specifically, the following types of data should be obtained and included in the SMART products:

    - Internal Consistency Check results for each functional element should be reported in the verification reports to establish a means of checking that the model uses consistent units throughout.

    - Results of SURVIAC sample data runs should be included in the validation reports to ensure that new versions of a model produce expected results for standard inputs. These results build confidence that model changes did not introduce errors.

    - Functional element correlation with manufacturer's data (when such data iare available) should be used for validation if actual test data is not available. Such correlation will provide almost as much confidence in model realism as test data comparisons.

- Any results of correlation with approved intelligence data (e.g., SIMVAL results) should be included in the validation reports. Inclusion of these results will provide all of the V&V history in one source and facilitate each accreditation.

4. The model managers for each of the models in the SMART domain should encourage their model users to adopt the SMART process for any application-specific V&V. Any V&V results should be provided to SURVIAC for incorporation into the SMART Accreditation Support Database.

5. The results of this study, relating to accreditation support information requirements, should be reviewed in one year to determine any changes that might evolve due to changing service policies.

8. REFERENCE LIST

8.1 Army

1 "Army Model and Simulation Management Program"; Army Regulation 5-11; Headquarters Department of the Army; 10 June 1992

2 "Applications of Verification, Validation and Accreditation on Army Models and Simulations; Draft, DA PAM 5-11; Headquarters Department of the Army; 2 April 1993

3 "Verification and Validation (V&V) and Accreditation of Models"; AMXSY-DA' 18 December 1989

4 U.S. Army Training and Doctrine Command (TRADOC) “Models and Simulations (M/S)"; Department of the Army Headquarters, United States Army Training and Doctrine Command

5 Operational Test and Evaluation Command (OPTEC) “Interim Policy Guidance (IPG) 92-2, Verification, Validation, and Accreditation (VV&A) of Modeling and Simulation (M/S) to Support or Supplement Operational Test and Evaluation Command; CSTE-MP (34od); 8 June 1992

6 "Accreditation Statement for the Joint Surveillance Target Attack Radar System (Joint STARS) Southwest Asia (SWA) 3.0 Radar Imagery System (RIS)"; United States Army Operational Test and Evaluation Command; CSTE-ZA (70)

7 "Procedures for Acceptance of Software by the Joint Technical Coordinating Group for Munitions Effectiveness (JTCG/ME)"; Joint Technical Coordinating Group for Munitions Effectiveness Aberdeen Proving Ground, Maryland 21005-5071, AMXSY-J (70); 2 October 1992

8 "VV&A Guidelines"; AMSAA; 9 November 1990

9 "Model VV&A Checklist"; Combat Support Division, AMSAA

10 "Some Thoughts on an Accreditation Process to Develop/Enhance the Credibility Models/Simulations; U.S. Army Material Systems Analysis Activity Aberdeen Proving Ground, Maryland, AMSAA; Philip H. Beavers; 17 May 1989

11 “Accreditation Report for the AMSAA Low Energy Laser Weapon Simulation (LELAWS)"; Report C-29, Combat Support Division Briefing Slides, U.S. Army Material systems Analysis Activity Aberdeen Proving Ground, MD 21005-5071; M. A. Vincent, B. W. Bradley, D.C. Muscietta, Thomas, P.H. Beavers; October 1992

12 "Evaluation of Air Defense Effectiveness (EVADE) Aircraft Survivability of Effectiveness Model, Verification, Validation and Accreditation"; Air Warfare Division Briefing Report, AMSAA; December 1992

13 "Accreditation Policy and Methodology for U.S. Army Applications of Expert Systems"; Strayer College, A paper submitted to Dr. Ghazi Alkhatib for computer information systems (CIS) 520 Artificial Intelligence and Expert Systems Theory and Application; Gregory G. Guernsey; November 1992

14 "Memorandum of Agreement (MOA) Between the U.S. Air Force Air Combat Command and the U.S. Army Space and Strategic Defense Command"; U.S. Army Space and Strategic Defense Command; 18 Feb 1993

8.2 Navy

1 Draft OPNAV Instruction "Verification, Validation, and Accreditation (VV&A) of Navy Models and Simulations"; 7 October 1993

2 Draft supplemental document "Principles for Verification, Validation, and Accreditation of Navy Managed Modeling and Simulation" 1 October 1993

3 "TOMAHAWK Simulation Management Policy"; PEO(CU) Instruction 5232.1; Program Executive Officer, Cruise Missile Project and Unmanned Aerial Vehicles Joint Project; 19 July 1993

4 "TOMAHAWK Simulation Management Plan"; PEO(CU) 5232/3; Program Executive Officer, Cruise Missile Project Unmanned Aerial Vehicles Joint Project; May 1993

5 "Verification, Validation, and Accreditation Technology"; A White Paper by D. K. Pace (JHU/APL); November 1992

6 "The State of Military Modeling, Lessons Learned From Model Reviews"; Center for Naval Analyses; Dennis P. Shea

7 "Review of Proposed Verification, Validation, and Accreditation (VV&A) Policies, Procedures, and Guidelines for Any Models and Simulations (M/S)"; Aircraft Weapons Integration Department (Fighter/Attack); David H. Hale

8 "Team Mike Meeting"; NAVSEA/Crystal City; Notes taken by Ron Ketchen, NAWCWPN CO24304; 2 October 1992

8.3 Air Force

1 "The OPTEC Accreditation Handbook": July 1992

2 "HQ AFOTEC/LG4 Guidelines for Modeling and Simulation (M/S) Application, Development, and Documentation"; Air Force Operational Test and Evaluation Center; Burton E. McKenzie, Jr., LTCOL USAF, Chief, Logistics Studies an Analysis Division; January 1991

3 "AFOTEC Modeling and Simulation Accreditation Process"; Draft POC:OAN; 5 February 1992

4 "Outline of MOSAIC VV&A Interim Final Report Draft"

5 "Verification, Validation, and Accreditation of MOSAIC Status Briefing"; Arvin Calspan Corporation Advanced Technology Center; 18 May 1993

6 "High-Resolution Conflict Simulation Conference"; Lawrence, Livermore National Laboratory; Proceedings; 3-5 November 1992

7 Draft Message HQUSAF/XOM 222000Z Oct. 93 "VV&A Interim Policy Guidance "

8.4 Other

1 "Validation and Verification of Computer Models Working Towards a Standard Procedure"; Briefing Slides, Physics and Electronics Laboratory; Briefed by Netherlands

2 "Moving Toward A DOD Instruction on VV&A"; Briefing Slides, RAND; Paul K. Davis; 24 May 1993

3 "Joint-Modeling and Simulation System (J-MASS) Program, Verification, Validation and Accreditation Guidelines"; Draft; March 1993

4 "DoD Modeling and Simulation (M&S) Management"; Department of Defense Directive 5000.59; January 4 1994

5 "Intelligence Support"; 5000.2 part 4, Section A; 23 February 1991

6 "Is It You or Your Model Talking? A Framework for Model Validation"; RAND, Project Air Force Arroyo Center National Defense Research Institute; James S. Hodge, James A. Dewar; 1992

7 "Generalizing Concepts and Methods of Verification, Validation, and Accreditation (VV&A) for Military Simulations"; RAND, National Defense Research Institute; Paul K. Davis; 1992

APPENDIX A

INTERVIEW LIST

ACTIVITIES & PEOPLE INTERVIEWED

AGENCY	NAME	INTERVIEW PAGE #
ARMY		
AMSAA (Army Materiel Systems Analysis Activity)	Wyoming (Duke) Paris Jeff Gavlinski MAJ Mike Barton Phil Beavers	1
OPTEC (Operational Test and Evaluation Command)	Greg Gurnsey Margaret Wolchiak	4
ATCOM (Aviation and Troop Command, formerly AVSCOM)	Dr. Tony Kassos	6
DCSOPS (Deputy Chief of Staff for Operations)	CAPT Simpson	7
NAVY		
CNA (Center for Naval Analyses)	Dr. Dennis Shea	8
NAVAIR (Naval Air Systems Command)	CAPT Morris	10
OPTEVFOR (Operational Test and Evaluation Force)	Jim Duff (TD) & CDR Barry Kelly	12
SPAWAR (Space and Naval Warfare Systems Command)	James Weatherly Gary Keck	15
JHU/APL 13N422 (Johns Hopkins University, Applied Physics Lab)	Dr. Dale Pace Simone Youngblood	16
PMA-281 (Cruise Missile Program Manager)	Gabriella Russell	17
AIR FORCE		
AFSAA (Air Force Studies and Analysis Activity)	Clayton J. Thomas David E. Anderson LTCOL Henry Pugh	19
AFOTEC (Air Force Operational Test and Evaluation Center)	Dr. Marion Williams LTCOL Walt Koozin	21 22
AWC (Air Warfare Center)	Don Giadrosich	24
AFDTC (Air Force Development Test Center)	Richard Woodard LTCOL Randy Enright Brad Atherton Dr. Choltia Posey Robert Jones	25
ASC (Aeronautical Systems Command)	Gerald Bennett Mike Weisenbach Dr. Jerry Arnett Jordan Wescott Christopher Pfledderer Douglas McCown	26 28 30
WL (MOSAIC) (Wright Laboratories - MOSAIC Project Manager)	Mike Murray	31
USAF/XOM (Headquarters U.S. Air Force)	Jim Vernon Dr. Al Murashige	32

OTHER		
SURVIAC (Survivability & Vulnerability Information Analysis Center)	Kevin Crosthwaite Dennis Detamore	33
J-MASS (Joint Modeling and Simulation System Project Manager)	Don Martinovich Dan Sammons	34
DMSO (Defense Modeling and Simulation Office)	John Freeman	35
OSD PA&E (Office of the Secretary of Defense, Program Analysis and Evaluation)	Dr. Pat Sanders	Briefed at SSG & DMSO mtgs

APPENDIX B

INTERVIEW GUIDE

ACCREDITATION REQUIREMENTS STUDY
INTERVIEW GUIDE

1 For what purpose(s) does your agency use M&S?

2 What is your accreditation process?

3 Does it conform to any of the process models we have already diagrammed? Which one?

4 Who has authority to accredit models for your use?

5 Is that authority defined in any instruction or charter?

6 If so, what is that document?

7 Is that instruction/charter agency-specific or service-wide?

8 Can we have a copy?

9 On what basis are accreditation decisions made?

10 Considering the various VV&A elements, (e.g. Data source verification, logical verification, code verification, comparison with test results, comparison with other model results, etc.) which ones are required for your accreditation? Which ones are desirable?

11 Is validation of any sort required prior to accreditation?

12 Considering the validation elements already listed, which ones are done? Are there any others?

13 Which elements would you consider most beneficial?

14 Must the validation have been done on the version of the model being accredited?

15 Are special tests run to validate a model, or are previous test data acceptable?

16 For the last few models accredited, what was the cost of any special testing or data collection which was done?

17 Have any models been accredited solely on the basis of past usage, or on the basis of "face validation"?

18 What agencies do you interface with to obtain information on VV&A history of the model you intend to accredit?

19 Is any verification required prior to accreditation?

20 Considering the verification elements already listed, which ones are done to support an accreditation decision?

21 Are there any others?

22 Is configuration management of a model required prior to accreditation?

23 To what extent?

24 Is configuration management handled in-house, or does your agency rely on configuration management activities from other agencies?

25 Describe any configuration management requirements imposed on the accreditation process, and any procedures used to fulfill them.

26 How are any validation, verification, or accreditation activities documented?

27 Are these activities and results published in any form by which other model users can become informed of the results and use them?

28 What are these forms, and can we have access to some typical accreditation reports?

29 What types of model information is needed to determine whether the model fulfills the analytical requirement? What model summary data would you want in a database?

30 Do you have any examples of criteria which you used as a basis for making an accreditation decision or in determining that a model was acceptable for a particular use?

31 In looking at the matrix of accreditation requirements, which ones are either required, desired, or considered acceptable to accredit a model.

32 Who else in this agency can we talk to concerning accreditation efforts?

33 Who else in your service should we be talking to about accreditation requirements?

AIR FORCE SPECIFIC QUESTIONS

For AFOTEC

34 Two guides exist for AFOTEC M&S accreditation; POC:OAN Draft of 5 Feb. 92 and the LG4 guide of Jan. 91. Which one(s) express AFOTEC policy? Who is Accrediting authority, M/S Committee or as appointed in Accreditation Plan?

35 LG4 guide says analysts are responsible for Configuration Control for M&S they develop. Does AFOTEC do any CM for existing models?

36 When using existing models, does AFOTEC require that the four documents (Management manual, Analysts Manual, Programmers Manual, & Users Manual) be available?

37 For existing models if manuals do not meet your standards, are they rewritten?

38 Should the DOT&E issues (identified on the separate issues sheet) be addressed or investigated as part of the SMART process?

NAVY SPECIFIC QUESTIONS

39 What relationship exists between the Navy VV&A plan drafted under SPAWAR sponsorship and the JACG initiative to develop a unified VV&A process for survivability models?

40 Of the SMART model set, only ESAMS is listed in the M&S catalogue being prepared by SPAWAR. Should the others be included?

41 Goal #10 for Team MIKE is to "establish a methodology/procedure for providing documentation, certification, and configuration management for Naval Warfare models." Do the SMART documentation, assessment reports, and CM plans meet this requirement?

42 Goal #7 is to "establish and catalog common data bases IAW the principles supporting Navy evolution toward common data bases through the NWTDB process, set forth in OPNAVINST 9410.5." Need more information about that instruction and related Navy policies on data base development.

ARMY SPECIFIC QUESTIONS

43 Is there an Organization Chart which shows the various Army organizations, committees, and activities which get involved in accreditation?

44 Any contacts in Army Model and Simulation Management Office (AMSMO), Office Deputy Chief of Staff for Operations (ODCSOPS), or MISMA who should be interviewed?

45 **For MISMA** What progress has there been on the MISMA master plan (referenced in the Jim Metzger brief) for credibility assessment? Is that AR 5-11?

46 **For AMSMO** What progress on the AMSMO "How to" handbook? Who is preparing it? Can we contact them for information gathering purposes? Who is Point of Contact (POC)?

47 Are accreditation procedures listed on pg. 6 of SAUS-OR memo dated 30 Oct 89 still complete & valid? What does the statement "*Review of how input data and scenario data are used or modified internal to the model."* mean?

48 Can I get a sample of a "good" V&V plan and V&V report?

49 **For OPTEC** Is the V&V documentation format (encl. 6 of OPTEC IPG 92-2) still valid? What is an "uncertainty analysis"?

50 Are any SMART models included in the list of Army "Touchstone" M&S? What aircraft survivability models are included?

51 AR 5-11 has provisions for accreditation of a model for a "Class of Applications". Define/describe a "class of applications".

52 Should SMART attempt to produce a V&V report supporting accreditation for a Class of Applications? If so what class(es) should be covered?

53 Should the SMART produced test data conform to AR 25-9 and the Army Data Encyclopedia? If so, what are the requirements and costs? Would Army provide funds to support tailoring data to these requirements? Who should funding requests of this nature be directed to?

54 What are some typical acceptability criteria which are used in evaluating a model for a class of applications?

55 Where can I get a copy of AR 25-1 and AR 25-9?